

CLAIMS

We claim:

1. A process for alkylating an aromatic hydrocarbon reactant with an alkylating agent to produce an alkylated aromatic product, said process comprising:

(a) introducing said aromatic hydrocarbon reactant and said alkylating agent into a reactor unit containing a plurality of sequentially arranged beds comprised of a first bed containing a first catalyst effective for alkylating said aromatic hydrocarbon reactant and a second bed downstream from said first bed and containing a second catalyst effective for alkylating said aromatic hydrocarbon reactant and having less catalytic activity than said first catalyst;

(b) alkylating in said first bed under alkylation conditions said aromatic hydrocarbon reactant with said alkylating agent to form a first effluent comprising a mono-alkylaromatic compound, an unreacted portion of the aromatic hydrocarbon reactant, and polyalkylated aromatic compounds,

(c) alkylating in said second bed under alkylation conditions at least a portion of said unreacted aromatic hydrocarbon reactant present in said effluent with said alkylating agent to form a product effluent, and

d) removing said product effluent from said reactor unit, said product effluent comprising a mono-alkylaromatic compound, an unreacted portion of the aromatic hydrocarbon reactant, and polyalkylated aromatic compounds.

2. The process of claim 1, wherein said alkylation conditions within the reaction zone comprise temperature and pressure conditions at which the aromatic hydrocarbon reactant is in a vapor phase.
3. The process of claim 1, wherein the molar ratio of the aromatic hydrocarbon reactant to the alkylating agent is from about 5 to about 25.
4. The process of claim 1, wherein the aging rate of the staged combination of the first and second catalysts is less than the aging rate of either catalyst individually.
5. The process of claim 1, wherein the first catalyst has an alpha value greater than the alpha value of the second catalyst.
6. The process of claim 1, wherein the first catalyst has an alpha value from about 60 to about 200 and the second catalyst has an alpha value from about 20 to about 100.
7. The process of claim 1, wherein the reactor unit comprises from 4 to 8 catalyst beds.
8. The process of claim 1, wherein the first and second catalysts each comprise the same molecular sieve.
9. The process of claim 1, wherein the first and second catalysts each has a crystal size of less than one micron.
10. The process of claim 1, wherein the first catalyst comprises a molecular sieve and a silica binder and the second catalyst comprises a molecular sieve and an alumina binder.

11. The process of claim 1, wherein the aromatic hydrocarbon reactant comprises benzene and the alkylating agent comprises ethylene.
12. The process of claim 11, wherein at least 65% of the total benzene introduced to the reactor unit is introduced in the first bed of the reactor.
13. The process of claim 1, wherein the first catalyst is at least 10% more active than the second catalyst for alkylation of the aromatic hydrocarbon reactant at the operating conditions of the first bed.
14. The process of claim 13, wherein the first catalyst is at least 25% more active than the second catalyst for alkylation of the aromatic hydrocarbon reactant at the operating conditions of the first bed.
15. The process of claim 14, wherein the first catalyst is at least 50% more active than the second catalyst for alkylation of the aromatic hydrocarbon reactant at the operating conditions of the first bed.
16. The process of claim 15, wherein the first catalyst is at least 100% more active than the second catalyst for alkylation of the aromatic hydrocarbon reactant at the operating conditions of the first bed.
17. A process for the vapor-phase ethylation of benzene comprising:
 - a) providing a multi-stage alkylation reaction zone having a plurality of series-connected catalyst beds, at least one of the series-connected catalyst beds containing a first alkylation catalyst comprising a zeolite and at least one subsequent catalyst bed containing a second alkylation catalyst comprising a zeolite, the first alkylation catalyst being more active for the ethylation of benzene than the second alkylation catalyst,

- b) introducing benzene and ethylene into the multistage alkylation reaction zone;
 - c) operating the multistage alkylation reaction zone at temperature and pressure conditions in which the benzene is in a vapor phase to cause vapor-phase ethylation of the benzene in the presence of the first and second alkylation catalysts to produce an alkylation product comprising a mixture of ethylbenzene and polyalkylated aromatic components; and
 - d) withdrawing the alkylation product from the multistage alkylation reaction zone.
18. The process of claim 17, wherein the feedstock has a benzene/ethylene molar ratio from about 5 to about 25.
19. The process of claim 17, wherein the zeolite in the first catalyst has a silica/alumina ratio from about 5 to about 200.
20. The process of claim 17, wherein the zeolite in the second catalyst has a silica/alumina ratio from about 5 to about 200.
21. The process of claim 17, wherein the multistage alkylation reaction zone comprises 4 to 8 catalyst beds.
22. The process of claim 17, wherein the zeolite of the first and second alkylation catalysts each has a crystal size of less than one micron.
23. The process of claim 17, wherein the first alkylation catalyst is at least 25% more active than the second alkylation catalyst for the ethylation of benzene at the operating conditions of the first bed of the reaction zone.

24. The process of claim 23, wherein the first alkylation catalyst is at least 50% more active than the second alkylation catalyst for the ethylation of benzene at the operating conditions of the first bed of the reaction zone.

25. A process for the vapor-phase reaction of ethylene with benzene, the process comprising:

- a) introducing benzene and ethylene, in a molar ratio of benzene to ethylene from about 5 to about 25 into a multi-stage alkylation reaction zone having a plurality of series-connected catalyst beds, at least one catalyst bed containing a first alkylation catalyst comprising a molecular sieve bound with silica binder and having an alpha value from about 60 to about 200 and at least one subsequent catalyst bed containing a second alkylation catalyst with an alpha value from about 10 to about 60;
- b) operating each stage of the alkylation multistage reaction zone at temperature and pressure conditions in which the benzene is in a vapor phase to produce an alkylation product comprising a mixture of ethylbenzene and polyalkylated aromatic components;
- c) withdrawing the alkylation product from the multistage alkylation reaction zone;
- d) separating the polyalkylated aromatic components from the alkylation product; and
- e) supplying at least a portion of the polyalkylated aromatic component along with benzene to a transalkylation reaction zone operated in the vapor or liquid phase under temperature and pressure conditions sufficient to cause transalkylation of the polyalkylated aromatic fraction to produce a transalkylation product having an enhanced ethylbenzene content and a reduced polyalkylated aromatic components content.

26. The process of claim 25, wherein the reaction zone comprises from 4 to 8 catalyst beds.

27. A process for the vapor-phase reaction of ethylene with benzene, the process comprising:

- a) introducing benzene and ethylene, in a molar ratio of benzene to ethylene from about 5 to about 25 into a multi-stage alkylation reaction zone having a plurality of series-connected catalyst beds, at least one catalyst bed containing a first alkylation catalyst comprising a molecular sieve bound with silica binder and having an alpha value from about 60 to about 200 and at least one subsequent catalyst bed containing a second alkylation catalyst with an alpha value from about 10 to about 60;
- b) operating each stage of the alkylation multistage reaction zone at temperature and pressure conditions at which the benzene is in a vapor phase to produce an alkylation product comprising a mixture of ethylbenzene and polyalkylated aromatic components;
- c) withdrawing the alkylation product from the multistage alkylation reaction zone;
- d) separating the polyalkylated aromatic components from the alkylation product; and
- e) supplying at least a portion of the polyalkylated aromatic component to the alkylation reaction zone of step (a) to cause transalkylation of the polyalkylated aromatic fraction to produce a transalkylation product having an enhanced ethylbenzene content and a reduced polyalkylated aromatic components content.

28. The process of claim 27, wherein the reaction zone comprises from 4 to 8 catalyst beds.